FRDM-K20D50M User's Manual

FRDM-K20D50M-UM

Rev. 1.0

Freescale Semiconductor Inc.
Microcontroller Solutions Group

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1 FRDM-K20D50M Overview

The Freescale Freedom development platform is a set of software and hardware tools for evaluation and development. It is ideal for rapid prototyping of microcontroller-based applications. The Freescale Freedom K20D50M hardware, FRDM-K20D50M, is a simple, yet sophisticated design featuring a Kinetis K series microcontroller, The K family microcontroller built on the ARM® Cortex™-M4 core with DSP capabilities. FRDM-K20D50M features a K20DX128VLH5, this device boasting a max operating frequency of 50MHz, 128KB of flash, a full-speed USB controller, and loads of analog and digital peripherals. The FRDM-K20D50M hardware is form-factor compatible with the Arduino™ R3 pin layout, providing a broad range of expansion board options. The on-board interfaces include an RGB LED, a 3-axis digital accelerometer, and a capacitive touch slider, and ambient light sensor.

The FRDM-K20D50M features the Freescale open standard embedded serial and debug adapter known as OpenSDA. This circuit offers several options for serial communications, flash programming and run-control debugging.

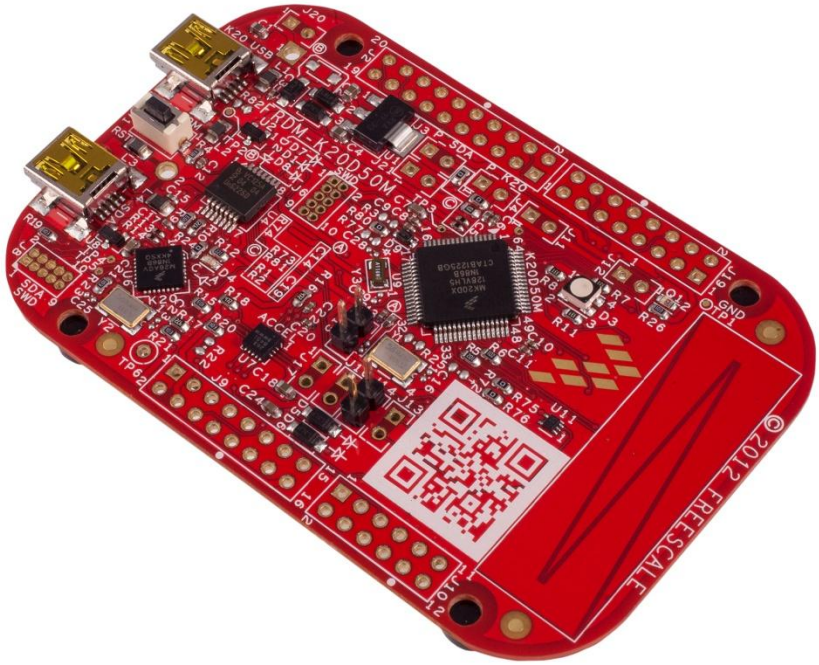


Figure 1 Freescale FRDM-K20D50M Overview

Contents

The TWR-K20D50M contents include:

- TWR-K20D50M board assembly
- 3ft A to mini-B USB cable for debug interface, serial communication and power
- Quick Reference card.

2 References documents

The table below provides a list of reference documents for the FRDM-K20D50M hardware. All of these documents are available online at www.freescale.com/ FRDM-K20D50M.

Table 1. FRDM-K20D50M **Reference Documents**

Filename	Description
FRDM-K20D50M Quick Start Package	Quick Start Guide and supporting files for getting started with the *FRDM-K20D50M*.
FRDM-K20D50M User's Manual	This document—overview and detailed information for the *FRDM-K20D50M* hardware.
FRDM-K20D50M Pinouts	Spreadsheet of pin connections for all MCU pins. Includes pinout for the I/O headers, Arduino R3 compatibility chart, and OpenSDA MCU pinout.
FRDM-K20D50M Schematics	PDF schematics for the *FRDM-K20D50M* hardware
FRDM-K20D50M Design Package	Zip file containing all design source files for the *FRDM-K20D50M* hardware
OpenSDA User's Guide	Overview and instructions for use of the OpenSDA embedded

3 Getting started

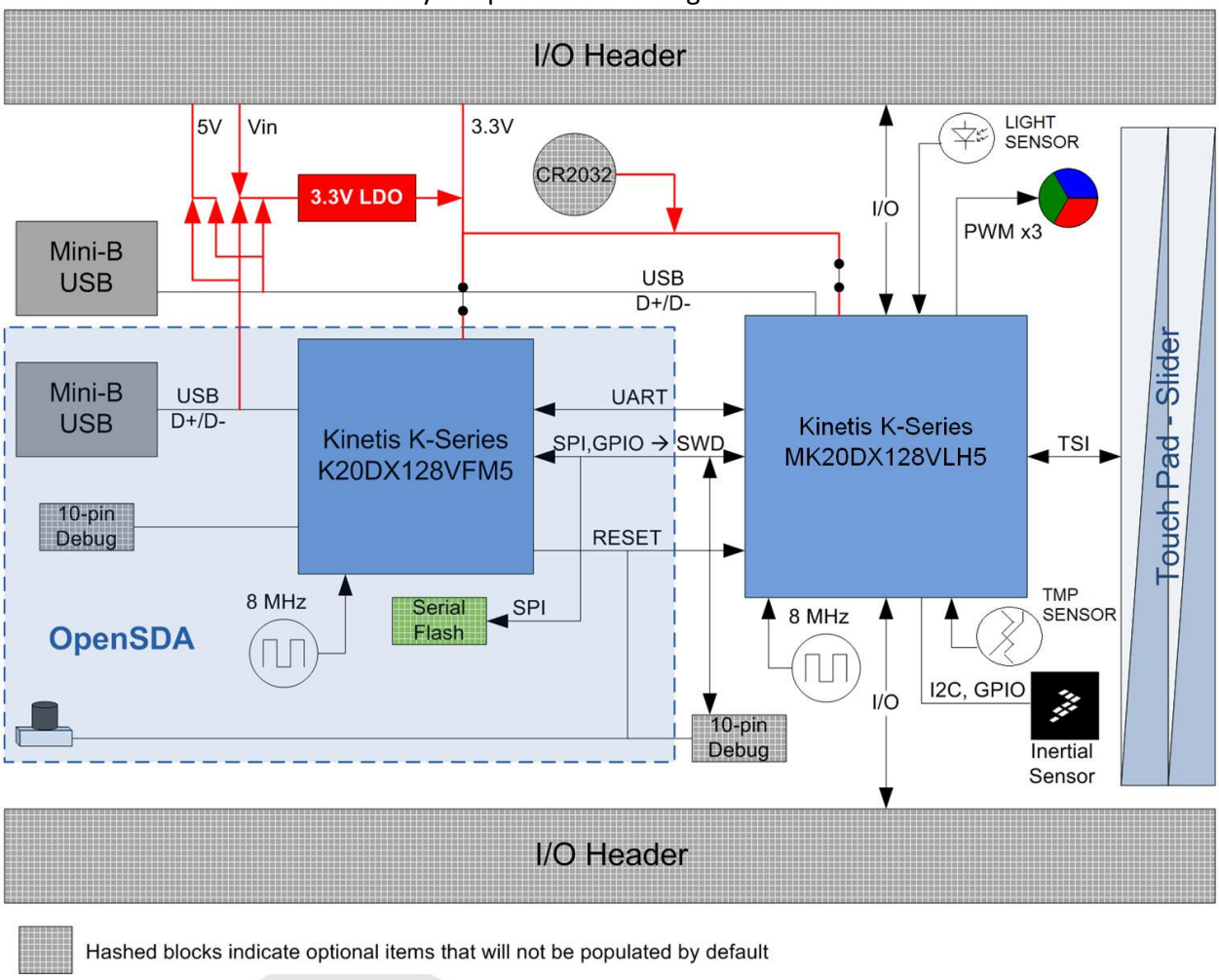
Refer to the *FRDM-K20D50M Quick Start Package* for step-by-step instructions for getting started with the *FRDM-K20D50M*. See the ***Jump Start Your Design*** section onwww.freescale.com/FRDM-K20D50M for the Quick Start Package and software lab guides.

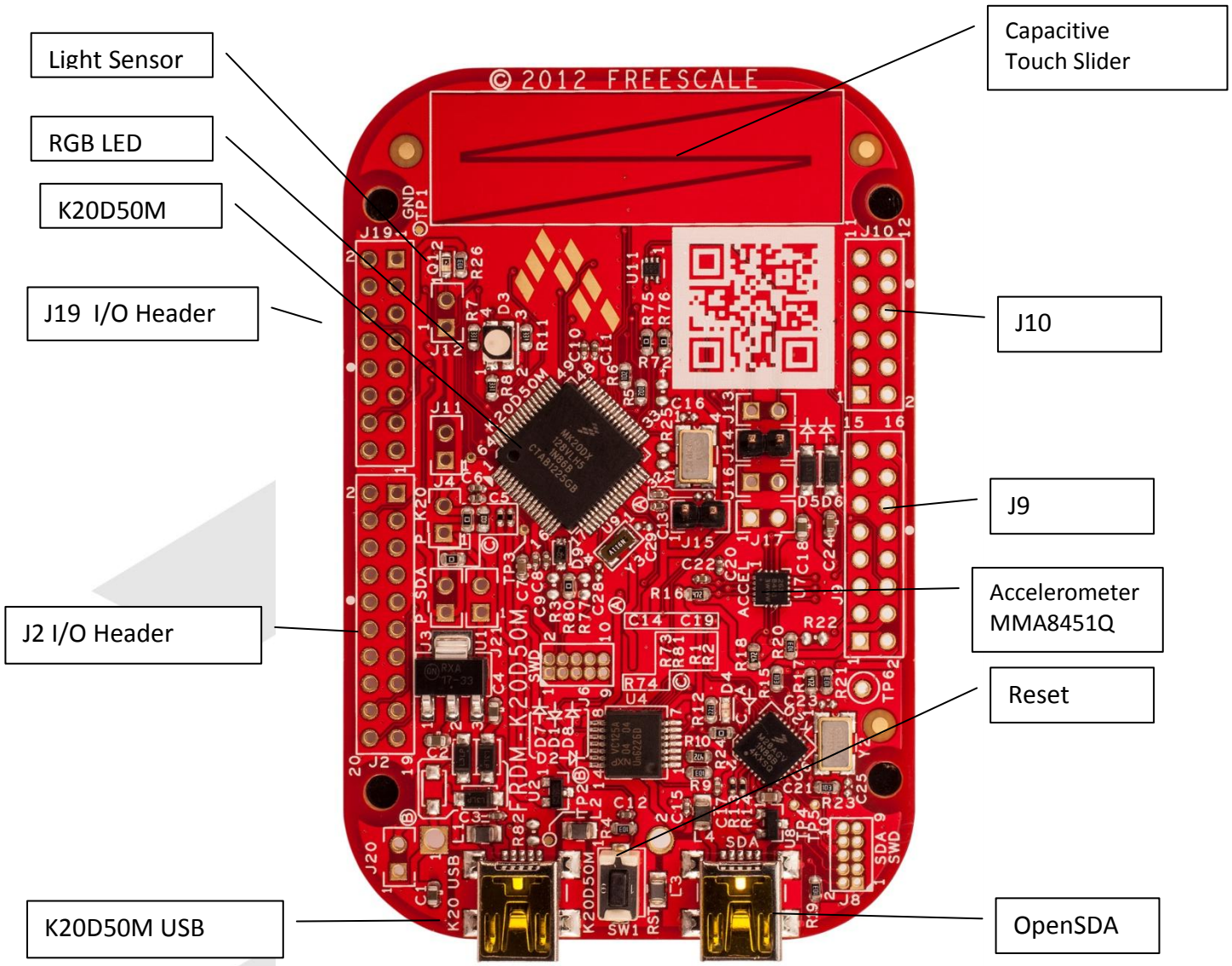
4 FRDM-K20D50M Hardwar Overview

- Arduino R3 compatibility
- MK20DX128VLH5 MCU (50 MHz, 128KB Flash, 16 KB RAM, 32 KB FlexNVM, Low power, 64LQFP package
- Dual role USB interface with mini-B USB connector
- Open SDA

- Capacitive touch slider
- Ambient light sensor
- MMA8451Q accelerometer
- Tri-color (RGB) LED
- Flexible power supply options – USB, coin cell battery, external source
- Battery-ready, power-measurement access points
- Easy access to MCU I/O via Arduino ™ R3 compatible I/O connectors
- Programmable OpenSDA debug interface with multiple applications available including:
    - Mass storage device flash programming interface
    - P&E Debug interface provides run-control debugging and compatibility with IDE tools
    - CMSIS-DAP interface: new ARM standard for embedded debug interface
    - Data logging application
-

Figure 1 shows a block diagram of the FRDM-K20D50M design. The primary components and their placement on the hardware assembly are pointed out in Figure 2.




Light Sensor
RGB LED
K20D50M
J19 I/O Header
J2 I/O Header
K20D50M USB
Capacitive
Touch Slider
J10
J9
Accelerometer
MMA8451Q
Reset
OpenSDA
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FRDM-K20D50M

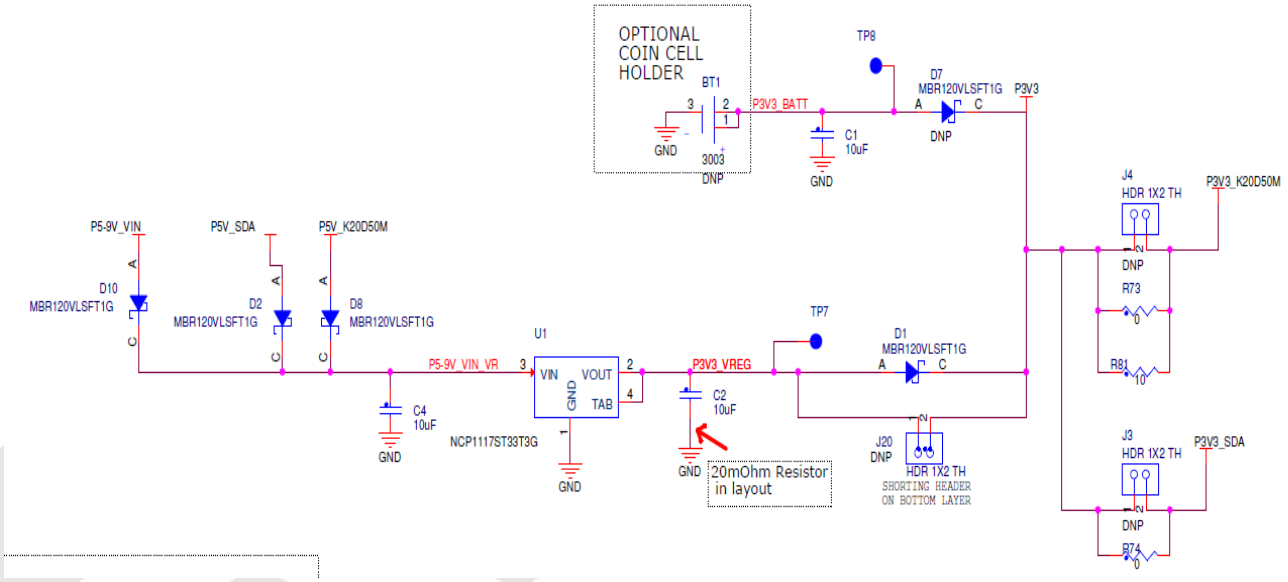
5 FRDM-K20D50M Hardware Description

5.1.1 Power Supply

There are multiple power supply options on the FRDM-K20D50M. It can be powered from either of the USB connectors, the VIN pin on the I/O header, an on-board coin cell battery, or an off-board 1.71-3.6V supply from the 3.3V pin on the I/O header. The USB and VIN supplies are regulated on-board using a 3.3V linear regulator to produce the main power supply. The other two sources are not regulated on-board. Table 2 provides the operational details and requirements for the power supplies.

Supply Source	Valid Range	OpenSDA Operational?	Regulated on-board?
OpenSDA USB	5V	Yes	Yes
K20 USB	5V	No	Yes
VIN Pin	4.3-9V	No	Yes
3.3V Pin	1.71-3.6V	No	No
Coin Cell Battery	1.71-3.6V	No	No

Note that the OpenSDA circuit is only operational when a USB cable is connected and supplying power to OpenSDA USB. However, protection circuitry is in place to allow multiple sources to be powered at once.



FRDM-K20D50M Power Supplies

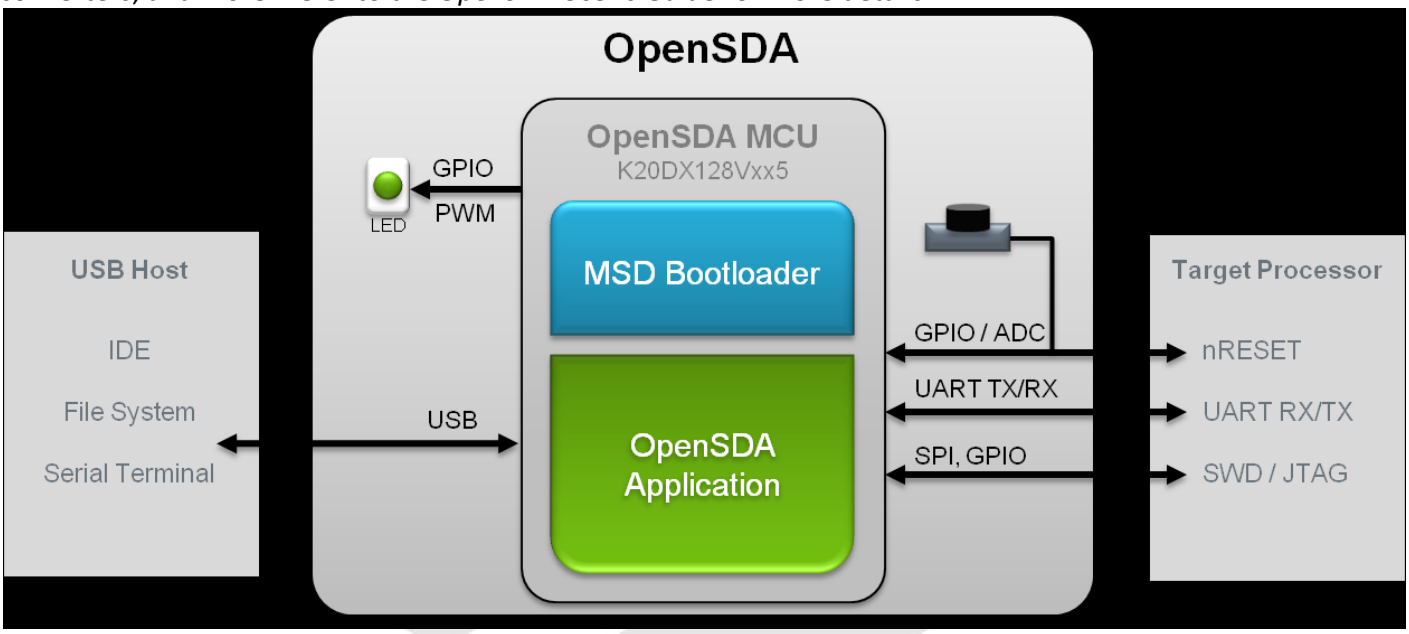
Power Supply Name	Description
P5-9V_VIN	Power supplied from the **VIN pin of the I/O headers** (J9 pin 16). A Schottky diode provides back drive protection.
P5V_SDA	Power supplied from the **OpenSDA USB** connector A Schottky diode provides back drive protection.
P5V_K20D50M	Power supplied from the **K20D50M USB** connector A Schottky diode provides back drive protection.
P3V3_VREG	**Regulated 3.3V supply**. Sources power to the P3V3 supply rail through a back drive protection Schottky diode. 1
P3V3_BATT	**Coin cell battery** supply voltage. Sources power to the P3V3 supply rail through a back drive protection Schottky diode.
P3V3	**Main supply rail** for FRDM-K20D50M assembly. May be sourced from P3V3_VREG, P3V3_BATT, or directly from the I/O headers (J9 pin 8)
P3V3_K20D50M	**K20D50M MCU supply.** Header J4 provides a convenient means for energy consumption measurements. 2
P3V3_SDA	**OpenSDA circuit supply.** Header J3 provides a convenient means for energy consumption measurements. 2
P5V_USB	Nominal **5V supplied to the I/O headers** (J9 pin 10). Sourced from either the P5V_K20D50M or P5V_OSDA supply through a back drive protection Schottky diode.

NOTES:

1) By default the linear regulator, U1, is a 3.3V output regulator. However, this is a common footprint that would allow the user to modify the assembly to utilize an alternative device such as a 1.8V or 2.5V regulator. The K20 microcontroller has an operating range of 1.71V to 3.6V
2) J3 and J4 are not populated by default. The two pins of these headers are shorted together by a trace on the bottom layer of the PCB. To measure the energy consumption of either the K20 or the OpenSDA MCU, the trace between these pins must first be cut. A current probe or a shunt resistor and voltage meter can then be applied to measure the energy consumption on these rails.

5.1.2 Serial and Debug Adapter (OpenSDA)

OpenSDA is an open-standard serial and debug adapter. It bridges serial and debug communications between a USB host and an embedded target processor as shown in Figure 4. The hardware circuit is based on a Freescale Kinetis K20 family microcontroller (MCU) with 128 KB of embedded flash and an integrated USB controller. OpenSDA features a mass storage device (MSD) bootloader, which provides a quick and easy mechanism for loading different OpenSDA Applications such as flash programmers, run-control debug interfaces, serial-to-USB converters, and more. Refer to the *OpenSDA User's Guide* for more details.

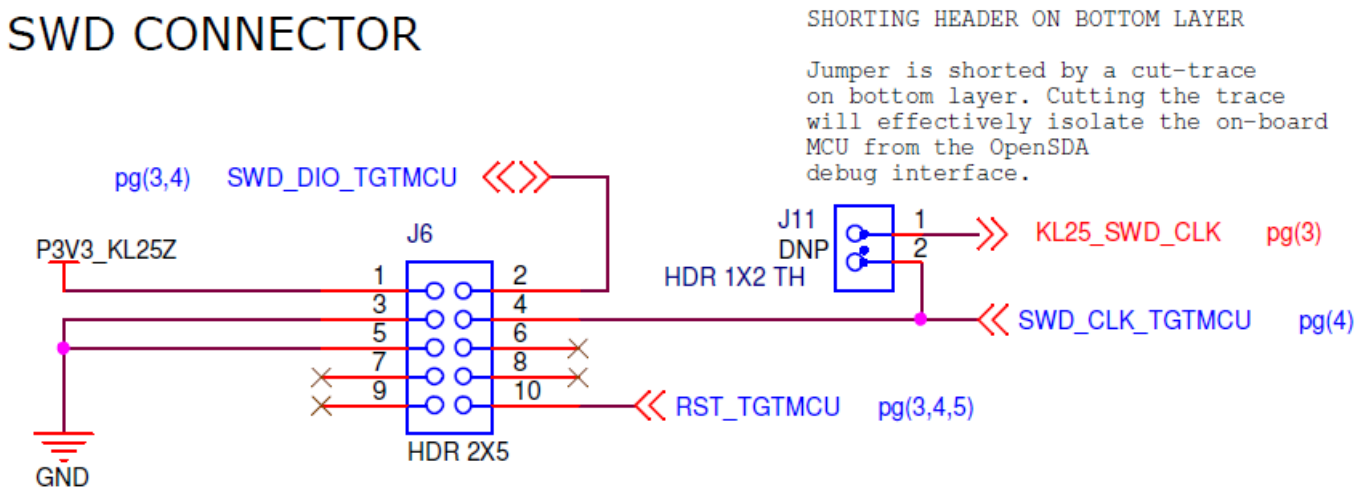


OpenSDA High-Level Block Diagram

OpenSDA is managed by another Kinetis K20 MCU built on the ARM® Cortex™-M4 core. The OpenSDA circuit includes a status LED (D4) and a pushbutton (SW1). The pushbutton asserts the Reset signal to the K20D128 target MCU. It can also be used to place the OpenSDA circuit into Bootloader mode. SPI and GPIO signals provide an interface to either the SWD debug port of the K20. Additionally, signal connections are available to implement a UART serial channel. The OpenSDA circuit receives power when the USB connector J7 is plugged into a USB host.

Debug Interface

Signals with SPI and GPIO capability are used to connect directly to the SWD of the K20. These signals are also brought out to a standard 10-pin (0.05") Cortex Debug connector (J6). It is possible to isolate the K20 MCU from the OpenSDA circuit and use J6 to connect to an off-board MCU. To Signals with SPI and GPIO capability are used to connect directly to the SWD of the K20. These signals are also brought out to a standard 10-pin (0.05") Cortex Debug connector (J6). It is possible to isolate the K20 MCU from the OpenSDA circuit and use J6 to connect to an off-board MCU. To accomplish this, cut the trace on the bottom side of the PCB that connects J11 pin 1 to J11 pin 2. This will disconnect the SWD_CLK pin to the K20 so that it will not interfere with the communications to an off-board MCU connected to J6.



Note that J6 is not-populated by default. A Samtec FTSH-105-02-F-D or compatible connector can be added to the J6 through-hole connector. A mating cable, such as a Samtec FFSD IDC cable, can then be used to connect from the OpenSDA of the FRDM-K20D50M to an off-board SWD connector.

Virtual Serial Port

A serial port connection is available between the OpenSDA MCU and pins PTA1 and PTA2 of the K20. Several of the default OpenSDA Applications provided by Freescale, including the MSD Flash Programmer and the P&E Debug Application, provide a USB Communications Device Class (CDC) interface that bridges serial communications between the USB host and this serial interface on the K20.

5.3 K20D50M Microcontroller

The target microcontroller of the FRDM-K20D50M is the MK20DX128VLH5, this is 50 MHz entry-level K20 USB microcontrollers (MCUs) are the lowest power Kinetis ARM® Cortex™-M4 devices with high feature integration in a small form factor, making them ideal for space- and cost-constrained applications. These MCUs offer 32 KB to 128 KB of flash memory and optional 32 KB of FlexNVM in 32-pin QFN (5 mm x 5 mm) to 64-pin LQFP packages. Peripheral options include full-speed USB Device/Host/On-The-Go with device charge detect capability, a 16-bit analog-to-digital converter (ADC), low-power touch-sensing interface and several general timing, communication and control peripherals.

Feature	Description

Ultra low power	-11 low-power modes with power and clock gating for optimal peripheral activity and recovery times. Stop currents of <190 nA (VLLS0), run currents of <280 uA/MHz, 4 µs wake-up from Stop mode -Full memory and analog operation down to 1.71V for extended battery life -Low-leakage wake-up unit with up to eight internal modules and sixteen pins as wake-up sources in low-leakage stop (LLS)/very low-leakage stop (VLLS) modes -Low-power timer for continual system operation in reduced power states
Flash, SRAM and FlexMemory	-32 KB-128 KB flash featuring fast access times, high reliability, and four levels of security protection -16 KB of SRAM -2 KB of FlexMemory (user-segmentable byte write/erase EEPROM for data tables/system data) -EEPROM with over 10M cycles and flash with 70 µsec write time (brownouts without data loss or corruption) -No user or system intervention to complete programming and erase functions and full operation down to 1.71V -FlexNVM adds up 32 KB for extra program code, data or EEPROM backup
Mixed-signal capability	-High-speed 16-bit ADC with configurable resolution -Single or differential output modes for improved noise rejection -500 ns conversion time achievable with programmable delay block triggering -Two high-speed comparators providing fast and accurate motor over-current protection by driving PWMs to a safe state -Optional analog voltage reference provides an accurate reference to analog blocks and replaces external voltage references to reduce system cost
Performance	-50 MHz ARM Cortex-M4 core with DSP instruction set, single cycle MAC, and single instruction multiple data (SIMD) extensions -Up to four channel DMA for peripheral and memory servicing with reduced CPU loading and faster system throughput -Cross bar switch enables concurrent multi-master bus accesses, increasing bus bandwidth -Independent flash banks allowing concurrent code execution and firmware updating with no performance degradation or complex coding routines

Timing and Control	-Two FlexTimers with a total of 10 channels -Hardware dead-time insertion and quadrature decoding for motor control -Carrier modulator timer for infrared waveform generation in remote control applications - Four-channel 32-bit periodic interrupt timer provides time base for RTOS task scheduler or trigger source for ADC conversion and programmable delay block
Human-Machine Interface	-Hardware touch-sensing interface (TSI) with up to 16 inputs -TSI operates in low power modes (minimum current adder when enabled) -TSI hardware implementation avoids software polling methods -High sensitivity level allows use of overlay surfaces up to 5 mm thick.
Connectivity and Communications	-Full-Speed USB Device/Host/On-The-Go with device charge detect capability - Optimized charging current/time for portable USB devices, enabling longer battery life - USB low-voltage regulator supplies up to 120 mA off chip at 3.3 volts to power external components from 5-volt input -Three UARTs (one UART supports RS232 with flow control, RS485, ISO7816 and IrDA while the other two UARTS support RS232 with flow control and RS485) -One Inter-IC Sound (I2S) serial interface for audio system interfacing -One DSPI module and one I2C module
Reliability, Safety and Security	-Memory protection unit provides memory protection for all masters on the cross bar switch, increasing software reliability -Cyclic redundancy check (CRC) engine validates memory contents and communication data, increasing system reliability -Independent-clocked computer operating properly (COP) guards against clock skew or code runaway for fail-safe applications such as the IEC 60730 safety standard for household appliances -External watchdog monitor drives output pin to safe state for external components in the event that a watchdog timeout occurs -This product is included in Freescale's product longevity program, with assured supply for a minimum of 10 years after launch

5.1.3 Clock source

The Kinetis K microcontrollers feature an on-chip oscillator compatible with three ranges of input crystal or resonator frequencies: 32-40 kHz (low freq. mode), 3-8 MHz (high freq. mode, low range) and 8-32 MHz (high freq. mode, high range). The FRDM-K20D50M is clocked from an 8 MHz crystal.

5.1.4 USB Interface

The Kinetis K microcontrollers feature a dual-role USB controller with on-chip full-speed and low-speed transceivers. The USB interface on the FRDM-K20D50M is configured as a full-speed USB device.
VREGIN must be powered to enable the internal circuitry of USB (by jumper J7)

5.1.5 Serial Port

The primary serial port interface signals are PTB0 UART0 RX and PTB17 UART0_TX. These signals are connected the OpenSDA

5.1.6 Reset

The RESET signal on the K20 is connected externally to a pushbutton, SW1, and also to the OpenSDA circuit. The reset button can be used to force an external reset event in the target MCU. The reset button can also be used to force the OpenSDA circuit into bootloader mode. Please refer to section 5.2, Serial and Debug Adapter (OpenSDA), for more details.

5.1.7 Debug

The MK20DX128VLH5 supports JTAG and SWD debug interface however only SWD debug interface is available on FRM-K20D50M board. However, an unpopulated 10-pin (0.05”) Cortex Debug connector, J6, provides access to the SWD signals. The Samtec FTSH-105-02-F-D or compatible connectors can be added to the J6 through-hole debug connector to allow for an external debug cable to be connected.

5.1.8 Capacitive Touch Slider

Two Touch Sense Input (TSI) signals, TSI0_CH11/PTB18, and , TSI0_CH12/PTB19 are connected to capacitive electrodes configured as a touch slider. Freescale’s Touch Sense Software (TSS) provides a software library for implementing the capacitive touch slider.

5.1.9 3-axis Accelerometer

A Freescale MMA8451Q low-power, three-axis accelerometer is interfaced through an I2C bus and two GPIO signals as shown in Table 4 below. By default, the I2C address is 0x1D (SA0 pulled high).

Table 4. Accelerometer Signal Connections

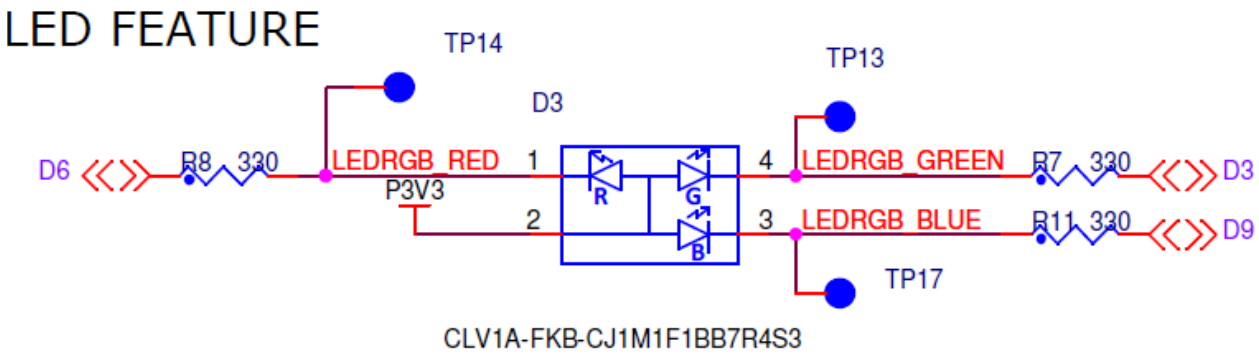
MMA8451Q	K20D50M
SCL	PTB0
SDA	PTB1
INT1	PTC11
INT2	PTC6

5.1.10 RGB LED

Three PWM-capable signals are connected to a red, green, blue LED, D3. The signal connections are shown in Table 5 below.

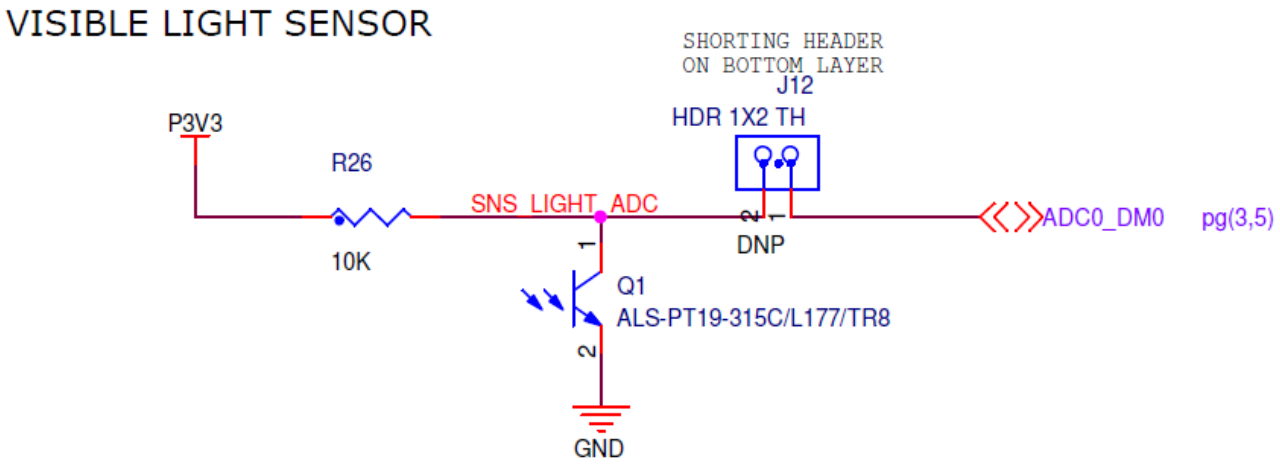
Table 5. RGB LED Signal Connections

RGB LED	K20
Red Cathode	D6 –PTC3 FTM0_CH2
Green Cathode	D3 – PTD4 FTM0 CH4
Blue Cathode	D9 - PTA2 FTM0-CH7



5.1.11 Visible light sensor

The FRDM-K20D50M has a visible light sensor that is connected to ADC0_DM0



5.1.1 Temperature sensor

FRDM-K20D50M is prepared for an external temperature sensor BD1020HFV-TR connected to ADC0-DM3.
Note: this sensor is not populated on the board.

5.1.2 Input/Output Connectors

The K20DX128VLH5 microcontroller is packaged in an 64-pin LQFP. Some pins are utilized in on-board circuitry, but many are directly connected to one of four I/O headers.

The pins on the K20 microcontroller are named for their general purpose input/output port pin function. For example, the 1st pin on Port A is referred to as PTA1. The I/O connector pin names are given the same name as the K20 pin connected to it, where applicable.

J19

PTE1	2	1	PTD0
PTE0	4	3	PTC11
PTA5	6	5	PTC5
PTD4	8	7	PTC6
PTC8	10	9	PTC7
PTA1	12	11	PTA4
PTC3	14	13	PTD7
PTC4	16	15	PTC9

J10

ADC0_DM0	11	12	PTB0
ADC0_DP0	9	10	PTB1
ADC0_DM3	7	8	PTD5
ADC0_DP3	5	6	PTD6
CMP1_IN3	3	4	PTC1
CMP0_IN5	1	2	PTC0

J2

PTA12	2	1	PTA13
PTA2	4	3	PTC10
PTC2	6	5	
PTD2	8	7	
PTD3	10	9	
PTD1	12	11	
GND	14	13	
VREFH	16	15	
PTB3	18	17	
PTB2	20	19	

J9

	15	16	P5-9V_VIN
	13	14	GND
	11	12	GND
	9	10	P5V_USB
	7	8	P3V3
	5	6	RST_TGTMCU
	3	4	P3V3
	1	2	SDA_PTD5

5.1.3 Arduino Compatibility

The I/O headers on the FRDM-K20D50M are arranged to allow compatibility with peripheral boards (known as shields) that connect to Arduino™ and Arduino-compatible microcontroller boards. The outer rows of pins (the even numbered pins) on the headers share the same mechanical spacing and placement as the I/O headers on the Arduino Revision 3 (R3) standard.